



# Center for Satellite and Hybrid Communication Networks

---



## Satellite Traffic Modeling and On-Board Switch Design

**Faculty:** A.M. Makowski and P. Narayan  
**Graduate Students:** M. Alzate, A. Das, M. Parulekar, C. Tsoukatos,  
S.-A. Yang  
**Industry Support:** GTE Labs  
**Other Sponsors:** ARL ATIRP Consortium

**Industry Advisory Board Meeting  
February 17, 1999**



# Satellite Traffic Modeling and On-Board Switch Design



- **Objectives**

- Develop concepts for onboard switching architectures to support high data-rate (up to 155 Mbps) multimedia applications;
- Develop performance evaluation methodologies and tools for:
  - (i) system design (e.g., buffer sizing, link capacity assignment);
  - (ii) efficient operations (e.g., flow control, QoS guarantees) in high-speed (up to 155 Mbps) networks.



# Satellite Traffic Modeling and On-Board Switch Design



- **Approach**
  - Develop techniques based on:
    - (i) Analysis (e.g., Statistical modeling, approximation methods, asymptotics);
    - (ii) Simulation models (e.g., OPNET)
  - Develop methodologies for:
    - (i) Multimedia traffic modeling;
    - (ii) Evaluation of component performance and end-to-end QoS.

# Accomplishments

- **Traffic models:** Have developed estimation algorithms for determining parameters of
  - discrete-batch Markov-arrival process (short-range dependent);
  - fractional Gaussian noise process (long-range dependent);
  - $M|G|^\infty$  input process (long-range dependent).

- **Traffic models:** Have developed  $M|G|_{\infty}$  models for compressed-video traffic:

- “G” is such that the resulting autocorrelation function

$$\rho(k) = e^{-\beta\sqrt{k}}, k = 0, 1, \dots,$$

- appropriately captures the statistical characteristics of compressed-video sequence;
- Have estimated robustness of models by comparing associated buffer performance with that of real video sequences.

- **Models for satellite link traffic:** Have investigated models for “framed” traffic
  - Using simple “on-off” models for terrestrial ATM cell traffic, have studied impact of various forms of framing, and resulting models for satlink traffic;
  - Have analyzed buffer performance for traffic model above as a first step towards onboard buffer dimensioning;
  - Have analyzed cell loss rates and buffering delays for traffic at cell level;
  - Have analyzed frame loss rates and buffering delays for traffic at frame level for specific framing schemes.

- **Light traffic interpolations for multiplexer driven by  $M|G|_{\infty}$  inputs:**
  - Have devised simple and efficient approximations;
  - Key performance metrics (viz., average buffer size and cell loss rates);
  - Interpolate light and heavy traffic behaviors;
  - Very different approximations in models: long-range dependent case.

# Plans for 1999-2000

- **Development of models for satellite link traffic:**
  - At the level of ATM cells:

Study impact of satellite link access schemes (TDMA, M-TDMA, FDMA, CDMA, DAMA) on D-BMAP and  $M|G|_{\infty}$  terrestrial traffic models;
  - At the level of frames:

Study impact of framing on D-BMAP and  $M|G|_{\infty}$  terrestrial traffic models;

Develop resulting satlink traffic models.
  - Multifractal vs. long-range dependence:

Understand short vs. long time scale behaviors



- **Recommendations for Onboard Switch Design:**

- Cell loss rates and buffering delays for traffic at cell level (D-BMAP and  $M|G|_{\infty}$  traffic models);
- Frame loss rates and buffering delays for traffic at frame level (D-BMAP and  $M|G|_{\infty}$  traffic models);
- Minimum input-output buffering requirements for meeting QoS specifications;
- Development of recommendations for onboard switching at cell level vs. frame level.

# Three-Year Perspective

- **Library of multi-media traffic models**
  - Short-range dependent;
  - Long-range dependent;
  - Satellite link traffic.
- **Onboard switching architectures**
  - Framing issues, frame sizes;
  - Minimum switch size and buffer dimension;
  - Multi-access methods and routing algorithms;
  - Effects of rate mismatch: thin routes and trunk traffic;
  - Overall performance enhancement by onboard processing.
- **Performance evaluation toolkit**
  - OPNET-based toolkit for modeling and performance evaluation. 10